AN IMPROVED AIR-CONDITIONED EQUIPMENT CABINET, IN PARTICULAR FOR TELEPHONY

The invention relates to the field of air-conditioned containers, for receiving equipment.

In numerous fields, such as telephony, equipment needs to be installed in zones that are subjected to climactic variations. In general, the equipment is installed in a closed container, commonly referred to as a "cabinet", so as to avoid being exposed directly to bad weather and/or acts of vandalism.

Since some such equipment is made up of components such as batteries or optical devices, for example, that cannot tolerate large variations in temperature, it is necessary for the containers in which they are installed to be air conditioned.

Thus, proposals have been made to fit containers with air/air type heat exchangers. Proposals have also been made to fit containers with double-skin type walls. However the performance of such devices was quickly found to be insufficient.

Containers were then devised comprising an inner wall defining a volume for receiving equipment and an outer wall protecting the container from the environment, with an central third wall being disposed between the inner and outer walls. The central wall and the inner wall define an inner compartment in which air coming from the inside volume circulates, while air coming from the outside circulates in the outer compartment defined between the central wall and the outer wall. The central wall thus acts as a heat exchanger between the air flows that circulate in the outer and inner compartments, respectively.

However, that solution ceases to be sufficiently effective when the temperature rises to above about 20°C, and it becomes practically useless when the outside temperature becomes greater than about 40°C. When the container is exposed directly to solar radiation, the

outer wall is raised to a very high temperature. Outside air circulating in the outer compartment is then heated excessively on coming into contact therewith and can no longer absorb heat from the air circulating in the inner compartment. In addition, that solution does not provide sufficient insulation when temperatures are very low. The air in the outer compartment absorbs heat from the air in the inner compartment via the central wall. The air in the inner compartment then acts through the inner wall to reduce excessively the temperature of the air surrounding the equipment, thereby interfering with the operation of the equipment.

Proposals have also been made to install air-conditioning devices inside containers, but firstly the reliability of such devices is not guaranteed, secondly they require maintenance action to be performed very frequently, and thirdly they increase the cost of containers very significantly.

Consequently, no prior art solution gives full satisfaction.

An object of the invention is thus to remedy the above-described drawbacks in full or in part by proposing a container capable of providing effective control over the temperature surrounding the equipment it contains, even when it is itself subjected to extreme temperatures, in particular to low temperatures down to –30°C or high temperatures up to +50°C. To this end, the invention provides a container comprising walls defining an inside zone capable of housing at least one piece of equipment, with at least one of its walls being constituted by at least three sub-walls spaced apart from one another in such a manner as to define at least a first air circulation space communicating with the outside of the container via at least two outside openings, and a second air circulation space communicating with the inside zone via at least two inside openings.

By definition, the term "first" sub-wall (or outer sub-wall) designates the sub-wall facing the outside of the container, the term "second" sub-wall (or inner sub-wall) designates the wall facing the inside zone, and the term "third" sub-wall (or central sub-wall) designates the sub-wall interposed between the first and second sub-walls.

The first sub-wall is made of thermally insulating material.

The third sub-wall is preferably constituted by a material for providing effective heat exchange between the first and second spaces.

As a result, at least one flow of internal air and at least one flow of external air are created that can exchange heat via the central sub-wall.

The structure of the container (or cabinet) thus serves not only to protect the equipment, but also to act as a heat exchanger.

The first sub-wall is preferably also made of thermally insulating material. This further improves thermal insulation, and temperature control is thereby made more effective.

In order to ensure that the invention is as effective as possible, it is desirable for there to be no thermal continuity between the first, second, and third sub-walls.

Furthermore, the container may be fitted with at least a first air circulator device enabling air to be sucked in from outside the container through at least a first outside opening, and then causing said air to circulate in the first space prior to being expelled to the outside through at least one second outside opening. A portion at least of the first air circulator device is preferably installed substantially in the second outside opening.

Instead of, or in addition to, the first air circulator device, it is also possible to provide at

least one second air circulator device enabling air to be sucked in from the inside zone via at least a first inside opening, and then causing the air to circulate in the second space prior to being expelled into the inside zone through at least one second inside opening. A portion at least of the second air circulator device is preferably installed substantially in the second inside opening.

It is preferable for the air circulator device, regardless of whether it is the first or the second device, to include at least one fan.

In addition, the container may include a control device enabling the operation of the first and/or second air circulator devices to be controlled. The control device may even be arranged in the form of a thermostat so as to regulate the temperature in the inside zone.

In an advantageous embodiment, the container has at least three walls constituted by sub-walls. Under such circumstances, it is preferable for the three walls to communicate with one another in such a manner as to constitute a single shaped element. By way of example, these three walls comprise two side walls and a top wall forming the roof of the container.

Finally, the direction of air circulation in the first space is preferably opposite to the direction of air circulation in the second space.

A particularly advantageous application of the container of the invention lies in housing telephone equipment.

Other characteristics and advantages of the invention appear on examining the following detailed description and from the sole accompanying figure which is a diagrammatic vertical section view showing an embodiment of a portion of an air-conditioned container of the invention. This figure may contribute not only to describing the invention, but it may also contribute to defining it, where appropriate.

The container (or cabinet) 1 shown has two side walls (in this case vertical walls) 2 and 3, a front wall 4 (likewise vertical), a bottom wall 5 constituting a supporting floor, a top wall 6 constituting a roof, and a rear wall (not shown) that is likewise vertical and placed substantially parallel to the front wall 4. The first and second side walls 2 and 3 are placed substantially parallel to each other, and the top wall 6 is placed substantially parallel to the bottom wall 5. Once assembled together, these walls define a closed inside zone 7 housing various pieces of equipment 8 (in this case three pieces of equipment). By way of example, the equipment 8 may comprise optical equipment for telephony together with a battery. In general, the front wall 4 is constituted by one or two doors giving access to the inside zone 7.

In the example shown, at least the top wall 6 and the first and second side walls 2 and 3 constitute a single folded element defining three faces of the cabinet 1. Naturally, the front wall 4 and/or the rear walls could also form parts of said folded elements. This single element, and consequently the three walls 2, 3, and 6 are constituted in this case by three sub-walls 9, 10, and 11.

The first sub-wall 9 is in contact with the outside air. The second sub-wall 10 faces the inside wall 7, in contact with the inside air. The third sub-wall 3 is interposed between the first and second sub-walls 9 and 10. These three sub-walls 9-11 are spaced apart from one another so as to define two air circulation spaces 12 and 13. More precisely, the first and third sub-walls 9 and 11 define a first or "outer" space 12, while the second and third sub-walls 10 and 11 define a second or "inner" space 13.

The outer space 12 communicates with the outside via at least two outside openings. In the example shown, three outside openings 14, 15, and 16 are provided. The

first outer opening 14 is formed at the end of the first side wall 2 situated close to the bottom wall 5, the second outside opening 15 is formed at the end of the second side wall 3 situated close to the bottom wall 5, and the third outside opening 16 is formed in the first sub-wall 9 of the top wall 6.

The inner space 13 communicates with the inside zone 7 (i.e. the inside of the cabinet 1) via at least two inside openings. In the example shown, three inside openings 17, 18, and 19 are provided. The first inside opening 17 is formed in the second sub-wall 10 of the top wall 6, the second inside opening 18 is formed at the end of the first sub-wall 2 that is situated close to the bottom wall 5, and the third inside opening 19 is formed at the end of the second side wall 3 situated close to the bottom wall 5.

The cabinet 1 preferably includes at least a first air circulator device 20 enabling outside air to be sucked in through the first and second outside openings 14 and 15 (inlets), and then caused to circulate in the outer space 12 prior to being expelled to the outside through the third outside opening (outlet). Sucking in outside air is preferred insofar as it makes it possible to avoid overheating at the air inlets.

In the example shown, the first air circulator device 20 is preferably installed in the sub-wall 9 of the top wall 6 in the third outside opening 16. It is constituted in this case by a fan sucking in outside air so that it flows inside the outer space 12 (between the first and third sub-walls 9 and 11) between the first and third outside openings 14 and 16 following arrows F1 and F2, and between the second and third outside openings 15 and 16 following arrows F'1 and F'2.

Also preferably, the cabinet 1 includes at least one second air circulator device 21 enabling inside air to be sucked in through the first inside opening 17 (inlet), and then made to circulate in the inner space 13 prior to

being expelled into the inside zone 7 via the second and third inside openings 18 and 19 (outlets).

In the example shown, the second air circulation device 21 is preferably installed on the sub-wall 10 of the top wall 6 in the first inside opening 17. It is constituted in this case by a fan sucking in inside air so that it flows in the inner space 13 (between the second and third sub-walls 10 and 11) between the first inside opening 17 and the second and third inside openings 18 and 19 following arrows F3 & F4 and F'3 and F'4.

By way of example, the fans 20 and 21 are powered by a 48 volt (V) battery located in the inside zone 7, and they are suitable for causing air to circulate in the outer and inner spaces 12 and 13 at a speed of not less than about 1.5 meters per second (m/s), for example.

Naturally, instead of using fans, it would be possible to use some other type of air circulator device, for example centrifugal blowers.

It is also possible to use only one air circulator device installed in the inner or outer air circuit. However the embodiment described is presently preferred insofar as it enables the inner and outer air flows to circulate in opposite directions, thereby increasing heat transfer between the inner and outer air flows.

In addition and as shown, the cabinet (or container) 1 may include a control device 22 for controlling the operation of the first and/or second air circulator devices. Various embodiments can be envisaged for the control device. It can be programmed to trigger the operation of one or more air circulator devices during certain periods of the day, or it may be coupled to an inner or outer temperature sensor so as to regulate the temperature in the inside zone 7 like a thermostat by controlling the operation of at least one of the air circulator devices.

It is thus possible to give priority to forced convection operation when temperatures are high and to natural convection operation (i.e. non-forced) when temperatures are low (the inner layer of air then constituting additional insulation). In addition, this makes it possible to limit the length of time the air circulator devices are in operation, and consequently to extend their lifetime while spacing maintenance operations apart. Furthermore, this makes it possible to deactivate the air circulator devices when the outside temperature drops below a threshold.

The first sub-wall 9 is made of a thermally insulating material so as to limit the effects of the sun during high temperatures and the effects of cold weather during low temperatures. For example, a material may be selected having a coefficient of thermal conductivity K that is less than about 1.5 watts per square meter per degree C ($W/m^2/°C$). By way of example, it is possible to select a material of the polyurethane foam type having thickness of about 20 millimeters (mm).

It is advantageous to select a material for the third sub-wall 11 (or central sub-wall) that makes it possible to maximize heat exchange between the inner and outer air flows. For example, it is possible to select a material presenting a coefficient of thermal conductivity K under natural convection (non-forced convection) of about 7 $W/m^2/°C$, so as to reach a value of at least 15 $W/m^2/°C$ under forced convection (i.e. when the air circulator devices are in operation. By way of example, it is possible to select aluminum sheet that is about 0.5 mm thick. This sheet may be shaped, e.g. into a U-shape, so as to increase the heat exchange area offered by the sub-wall 11.

In order to increase the heat exchange area offered by the sub-walls 9-11, it is possible to use plates that are corrugated, for example at a pitch of 20 mm.

By means of the invention, it is now possible to control temperature variations inside the cabinet to within a few degrees, for example.

Furthermore, it is now possible to use the cabinet effectively under temperature conditions lying in the range about —30°C to +50°C.

The invention is not limited to the container embodiments described above merely by way of example, and covers any variant that the person skilled in the art can devise within the ambit of the following claims.

Thus, dual air circulation is described in two side walls and a top wall (or roof). However, dual air circulation could be provided in the roof only, and/or in one or more side walls, including the rear wall, or even in the bottom wall and/or the front wall.

As described, the inner and outer air circulation spaces have two inlet openings and one outlet opening or one inlet opening and two outlet openings. However, the invention applies equally well to spaces having a single inlet opening and a single outlet opening, or a plurality of inlet openings and a plurality of outlet openings with some of them optionally fitted with respective air circulator devices.

The inner and outer air circulation spaces are described respectively as presenting an inner outlet opening and an outer outlet opening in the front wall. However the openings could be placed in any other position providing they enable air to circulate inside inner and outer spaces. The same applies for the positions of the inner outlet openings and the outer inlet openings.

A cabinet is described in which the air circulator devices are placed on the top wall (or roof), however said devices could be placed on any other wall made up of three sub-walls.